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The root-hairs of Coniferæ.

Dr. C. von Tubeuf closes a series of papers entitled, "Die Haarbildungen der Coniferen" in *Forstlich-naturwissenschaftliche Zeitschrift* with an account of the root-hairs of the Coniferæ,¹ of which the following is an abstract.

Of the root-hairs of Coniferæ little is known. In the few instances in which they have been observed they have been considered functionless. Schwarz found among all the species of Pinus and Abies observed, only Abies obovata sometimes with very short hairs which could scarcely be of any importance in absorbing water.

Strasburger states² that root-hairs are entirely wanting in species of Thuja, Sequoia, and Araucaria; are present exceptionally in Ephedra, sparingly in Pinus spp., and abundantly only in Taxus.

But von Tubeuf finds twenty-four species capable at least of producing root-hairs, and though no root-hairs were found on seven species he thinks it not certain that these species do not, at other times or under other conditions, form root-hairs.

On firs (*Picea excelsa*) three to six years old, few or no hairs were found between Feb. 28th and May 28th, but by June 28th the many young rootlets were clothed with many hairs which were present up to Nov. 28th.

The shape of the hairs is very various. In the Abietineæ they are always very long filaments and arise at a considerable distance from the tip of the root and from the second or third layer of the cortex, breaking through the outer cells, which slough off. Among the Taxaceæ, only Ginkgo has long thin-walled filamentous hairs. Taxus has very short rigid hairs whose walls are finely papillose. The hairs of *Torreya* and *Cephalotaxus*, having a very broad base, are mostly conical and very numerous, arising close behind the root tip.

The function of the root-hairs appears to be that of these structures elsewhere, viz.: to increase the surface by which water and food materials are absorbed. Frank combats the idea that they can suffice for this work and thinks that it is properly accomplished only when fungi (which he calls "Baumammen") invest the lateral roots as a mycorrhiza. From

¹ Forstl.-naturwiss. Zeits. 5: 173-193. pls. 3. My 1896.

² Coniferen u. Gnetaceen 343.

his *Lehrbuch der Botanik* it is not apparent that the Coniferæ form any root-hairs but one is left to infer that they are supplied exclusively through the fungi. Indeed he says (op. cit. 259) that mycorrhiza is a constant phenomenon in all forest trees of Cupuliferæ, Betulaceæ and Coniferæ; that this symbiosis has been found everywhere it has been sought, in all sorts of soils; that the fungus is present from the first year of the tree throughout its life upon all the absorbing roots; that the entire absence of root-hairs is a striking peculiarity of mycorrhiza; and that the tree receives water and food materials only through the mycorrhiza fungus. These statements are repeated essentially in his "Die Krankheiten der Pflanzen" (1895) and are much more radical than his earlier ones, in which he speaks of root-hairs of pines as normal in humus-free soils while mycorrhiza generally appears in humus soils. In all his publications he recognizes only one form of mycorrhiza which he calls the ectotrophic.

But Sarauw in 1893 had found intracellular mycelium in *Cedrus* and in *Taxus*. Von Tubeuf, also investigating numerous conifers in all situations, has discovered that an intracellular mycelium occurs very commonly among the living cells of the cortex in many species of certain families so that Frank's *endotrophic* mycorrhiza has an unexpectedly wide distribution.

In all Abietinæ, and in this family alone, ectotrophic mycorrhiza may occur either (a) as a purely external jacket, or (b) as a jacket sending hyphæ into the intercellular spaces of the cortex, or (c) as an intracellular mycelium only, with root-hairs. It was found that all Abietinæ are capable of producing root-hairs *at the same time*. Endotrophic mycorrhiza occurs in very many conifers of other families, agreeing neither with Frank's ericaceous nor orchidaceous types, but constituting a coniferous type, characterized by having the mycelium in a deep-seated zone of the cortical cells, the outer ones being free from it, and without special connection with the outer hyphæ as is the case in ectotrophic mycorrhiza. It does not affect the formation of root-hairs, which are often luxuriantly developed on mycorrhizal roots. The abundance of the hairs suggests that they are functional and experiments demonstrated this. Plants were cultivated in sterilized soils with artificial fertilizers; they developed normally, produced abundant root-hairs and grew vigorously for two years.—R.